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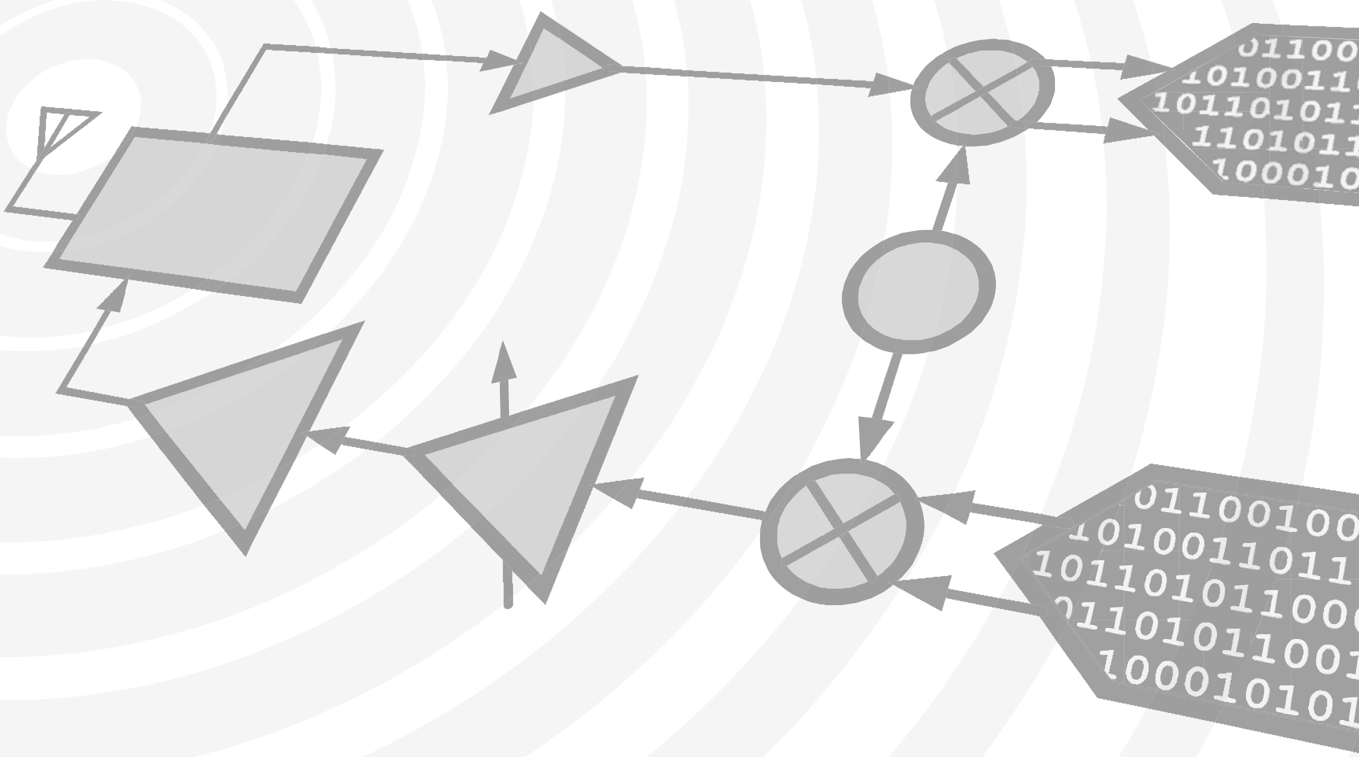

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RF & LO Port Designations for the HMC141 and HMC142 Double-Balanced Mixers

Although the mixers operate acceptably when RF & LO ports are interchanged, use the following guidelines for best performance.

Downconverter Operation

Use the Datasheet Outline Drawing (DOD) to determine port designation for typical downconverter performance per the HMC141/142 data sheet.

- Apply RF Input to RF Port so labelled on DOD and on MMIC die.
- Apply LO Input to LO Port so labelled on DOD and on MMIC die.
- Access IF Output at IF Port so labelled on DOD and on MMIC die.

Upconverter Operation

Reverse the port designation specified by the Datasheet Outline Drawing (DOD) for typical upconverter performance per the HMC141/142 data sheet on page 4-14.

- Apply IF Input to IF Port so labelled on DOD and on MMIC die.
- Apply LO Input to RF Port so labelled on DOD and on MMIC die.
- Access RF Output at LO Port so labelled on DOD and on MMIC die.

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RF & LO Port Designations for the HMC143 and HMC144 Double-Balanced Mixers

Although the mixers operate acceptably when RF & LO ports are interchanged, use the following guidelines for best performance:

Upconverter & Downconverter Operation

The RF & LO port markings on the MMIC die are correct and are consistent with the connection designated in the Datasheet Outline Drawing (DOD) found on the HMC143/144 data sheet.

Use the Datasheet Outline Drawing (DOD) to determine port designation for typical performance per data sheet.

Use the same port designations for both upconverter & downconverter operation.

For Example, in Downconverter Operation:

- Apply RF Input to RF Port so labelled on DOD and labelled “RF” on the MMIC die.
- Apply LO Input to LO Port so labelled on DOD and labelled “LO” on the MMIC die.
- Access IF Output at IF Port so labelled on DOD and on MMIC die.

For Example, in Upconverter Operation:

- Apply IF Input to IF Port so labelled on DOD and on MMIC die.
- Apply LO Input to LO Port so labelled on DOD and labelled “LO” on the MMIC die.
- Access RF Output at RF Port so labelled on DOD and labelled “RF” on the MMIC die.

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HIGH IP3 MIXERS FOR CELLULAR APPLICATIONS

Introduction

The explosive growth in the Cellular market over the last few years has created a demand for ever smaller infrastructure equipment to be used for in-building applications and other space limited installations, where the traditional large multiple rack base station is not feasible. The infrastructure equipment consists of digital call processing and an analog transmitter/receiver section. The RF section of a typical cellular transceiver is shown in figure 1.

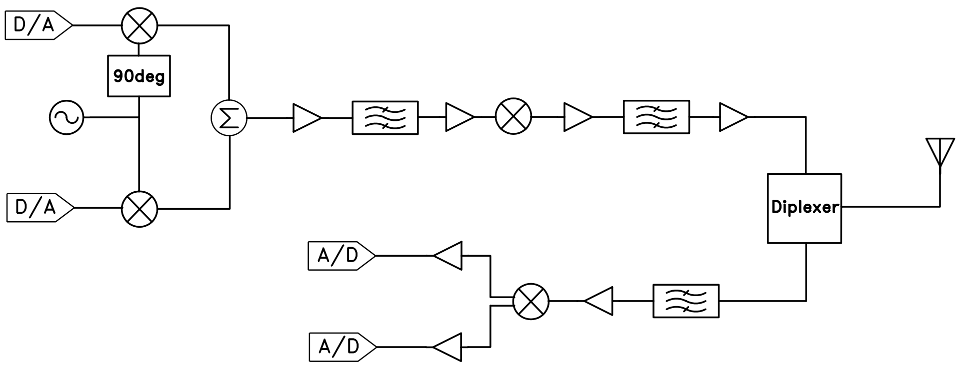

Figure 1 – Transceiver block diagram

Cellular communications employ many different and complex modulation schemes to transmit voice and data. Table 1 lists the characteristics of several popular cellular standards. These standards employ modulation methods that increase the peak to average power of the transmitted signal in proportion to the number of channels being transmitted. This, in turn, requires the receiver to have high linearity to minimize distortion of the channel.

Communications Standard	Mobile Frequency (MHz)	Channel Bandwidth (MHz)	Modulation Scheme	Peak to Average Power Ratio
CDMA	Rx: 460 - 468 869 - 894 1930 - 1990 2110 - 2170 Tx: 450 - 458 824 - 849 1850 - 1910 1920 - 1980	1.25	QPSK/OQPSK	9 to 10 dB
WCDMA	(FDD) Rx: 2110 - 2170 Tx: 1920 - 1980 (TDD) 1900 - 1920 2010 - 2025 unpaired spectrum	5	QPSK	8 to 9 dB
GSM/EDGE	Rx: 460 - 468 488 - 496 869 - 894 925 - 960 1805 - 1880 1930 - 1990 Tx: 450 - 458 478 - 486 824 - 894 880 - 915 1710 - 1785 1850 - 1910	0.2	GMSK 8-PSK (EDGE only)	1 to 2 dB
TDMA	Rx: 869 - 894 1930 - 1990 Tx: 824 - 849 1850 - 1910	0.03	π/4 DQPSK	3 to 4 dB

Table 1 – Popular cellular phone standards

HIGH IP3 MIXERS FOR CELLULAR APPLICATIONS

Figure 2 shows the frequency spectrum of a single-carrier CDMA waveform. The main channel contains the desired information to be transmitted or received. The "shoulders" of the spectrum are created by intermodulation products generated within the main channel. Error Vector Magnitude (EVM) and Bit Error Rate (BER), which are parameters commonly used to quantify the quality of the digital channel, are adversely affected by distortion or interference in the main channel. Adjacent channels, which coincide in frequency with the "shoulders" of the CDMA channel, will suffer interference due to the excess energy contained in the shoulders. Adjacent Channel Power Ratio (ACPR) is a measure of the amount of power in the "shoulders" relative to the main channel power and also serves as a measure of the linearity of the channel.

The major contributors to channel distortion in a cellular receiver are the front-end Low Noise Amplifier (LNA) and mixer. This application note will discuss the performance requirements for high linearity mixers used in the cellular receiver chain.

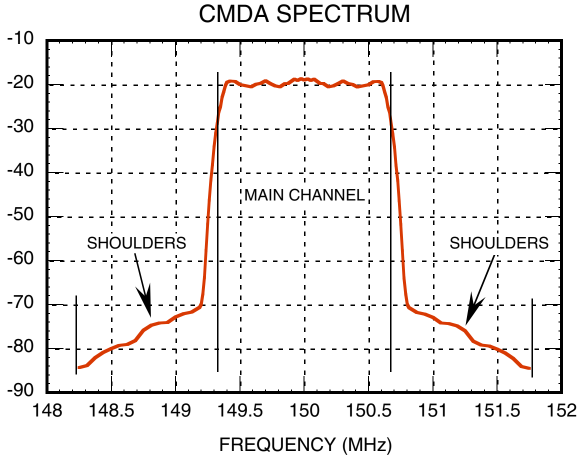

Figure 2 – CDMA channel frequency spectrum

Cellular Receiver Front End

In order to understand the significance of mixer performance parameters to the cellular receive chain, a system level simulation of a receiver front end was performed using =SPECTRASYS=[1]. The system simulation allowed us to see the effects of mixer nonlinearity, spurious performance and isolation simultaneously on the received channel.

The schematic block diagram that was entered into the simulation software is shown in figure 3. The simulation was created to show the effect of an interferer landing in the frequency band of interest, once the signals are down converted in the receiver.

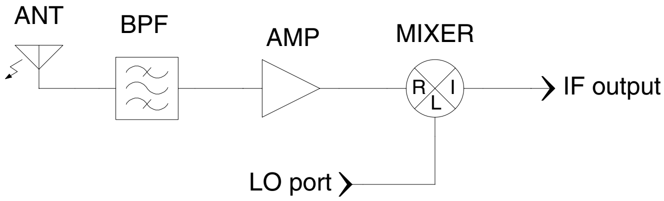

Figure 3 – Receiver simulation schematic block diagram

The mixer model used allowed us to enter a table containing the mixer spurious levels based on measured mixer performance. The values for the table and the other performance parameters (see figure 4) were taken directly from the datasheet of the HMC400MS8 mixer. Figure 5 shows the results of the simulation, as seen at the IF output of the mixer. For this simulation, the RF input frequency was 1880 MHz, the LO frequency was 1780 MHz, and an interferer was at 1830 MHz (at the RF port of the mixer). The 2x2 spur, created by the LO and the interferer, lands directly in the center of the received channel at 100 MHz. While not visible in the spectrum of the channel spectrum itself, the spur does degrade EVM and BER.

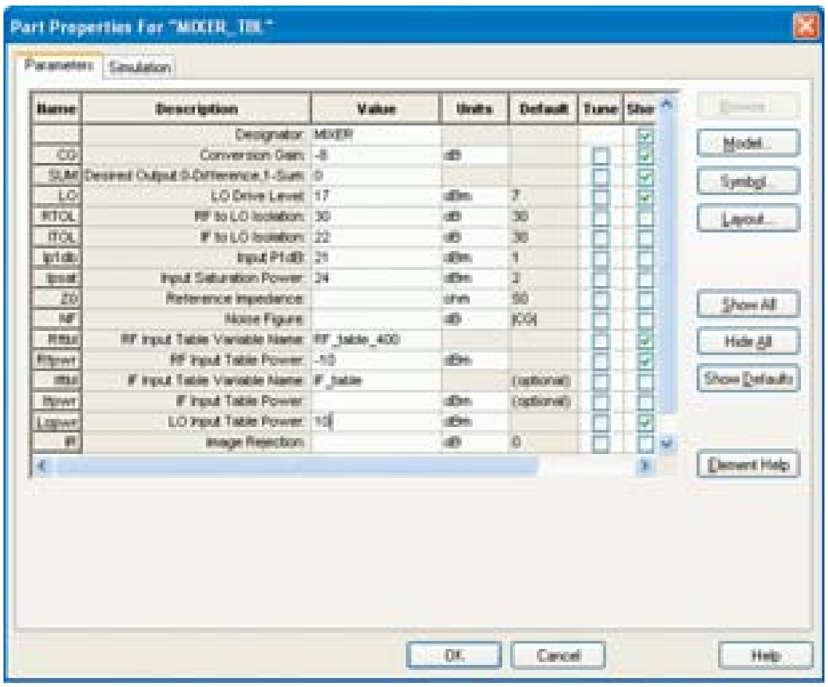

Figure 4 – =SPECTRASYS= mixer parameters

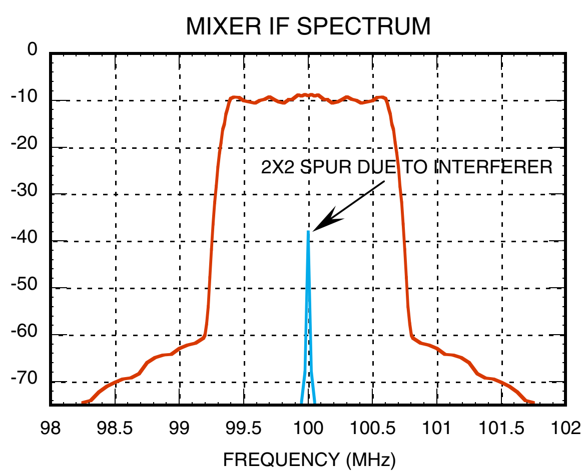

Figure 5 – Spur inside digital channel

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Selecting the Right Mixer

When selecting a high IP3 mixer, consideration must be given to other important parameters including LO drive level, isolation and spurious performance. Hittite Microwave Corporation uses a single-ended topology for the mixers with input IP3 >+30 dBm and a double-balanced approach for mixers with input IP3 in the +25 to +30 dBm range. Table 2 lists the family of high IP3 mixers from Hittite Microwave Corporation.

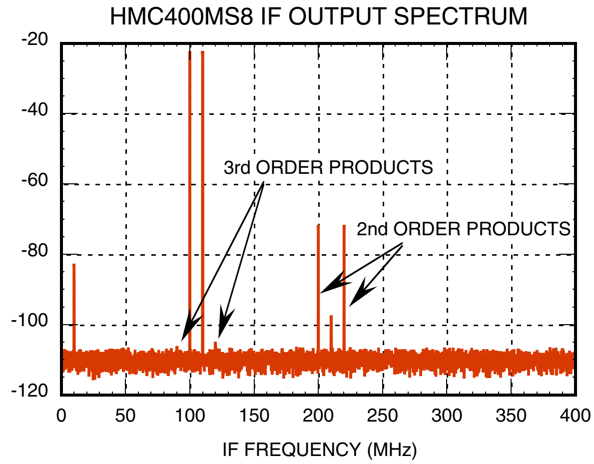
Part Number	RF Frequency (MHz)	IF Frequency (MHz)	IP3 (dBm)	LO (dBm)	Conversion Gain (dB)	Type of Mixer
HMC387MS8	300-500	DC-150	32	17	-9.5	sgl-end
HMC400MS8	1700-2200	DC-300	36	17	-9	sgl-end
HMC399MS8	740-960	DC-250	35	17	-8.5	sgl-end
HMC485MS8G	1700-2200	50-300	34	0	-9	sgl-end
HMC402MS8	1800-2200	DC-500	31	17	-8.5	sgl-end
HMC304MS8	1700-3000	DC-800	30	17	-9	sgl-bal
HMC350MS8	600-1200	DC-300	27	19	-7.5	dbl-bal
HMC351S8	700-1200	DC-300	26	19	-8	dbl-bal
HMC316MS8	1500-3500	DC-1000	25	17	-8	dbl-bal
HMC216MS8	1300-2500	DC-650	25	3-11	-9	dbl-bal

Table 2 – High IP3 mixers from Hittite Microwave

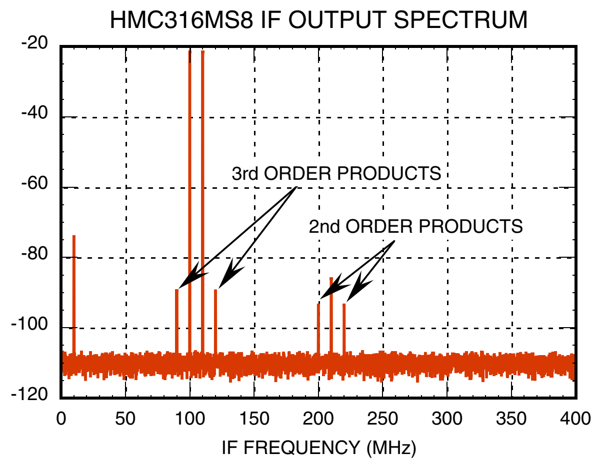
For applications where spurious and isolation performance is secondary to IP3, a single-ended mixer with the highest IP3 performance is the best choice. For applications with critical spurious issues, a double-balanced mixer with high IP3 performance is the best choice. This is often the case for a receiver that tunes over a wide IF bandwidth, where narrow IF filters cannot be used.

Figure 6 contrasts the simulated IF output spectrum for a single-ended mixer and a double-balanced mixer. For the simulation in figure 6, two tones separated by 10 MHz are injected into the RF port of the mixer and the desired 100 MHz IF signal is viewed in the spectrum analyzer output. Figure 6(a) shows the performance of the HMC400MS8 single-ended, high-IP3 mixer. This mixer has an input IP3 of approximately +35 dBm and 2x2 spurious suppression of -59 dBc. As expected, the excellent IP3 performance places the third-order products near the noise floor, while the second order products are clearly visible and at their expected level.

In Figure 6(b), the double-balanced HMC316MS8 mixer, with an input IP3 of +25 dBm and 2x2 spurious suppression of -77 dBc is shown. The tradeoff between input IP3 and spurious performance is clearly visible.



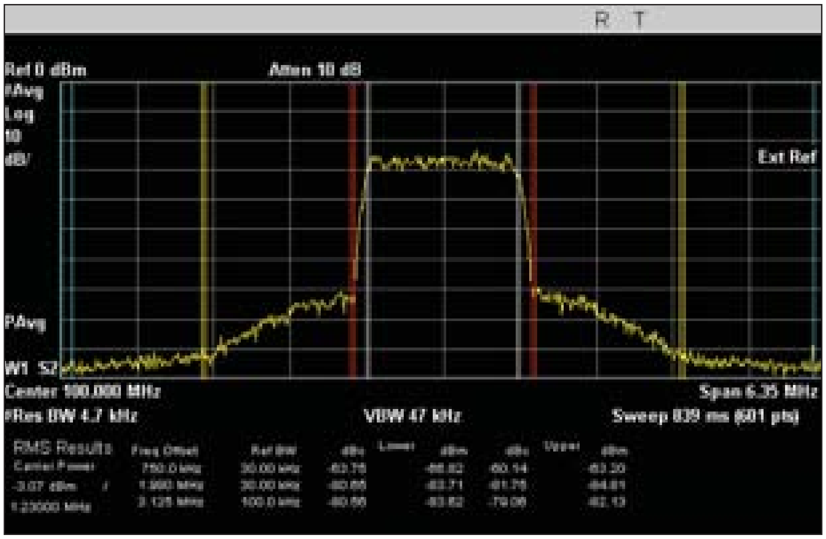
(a)



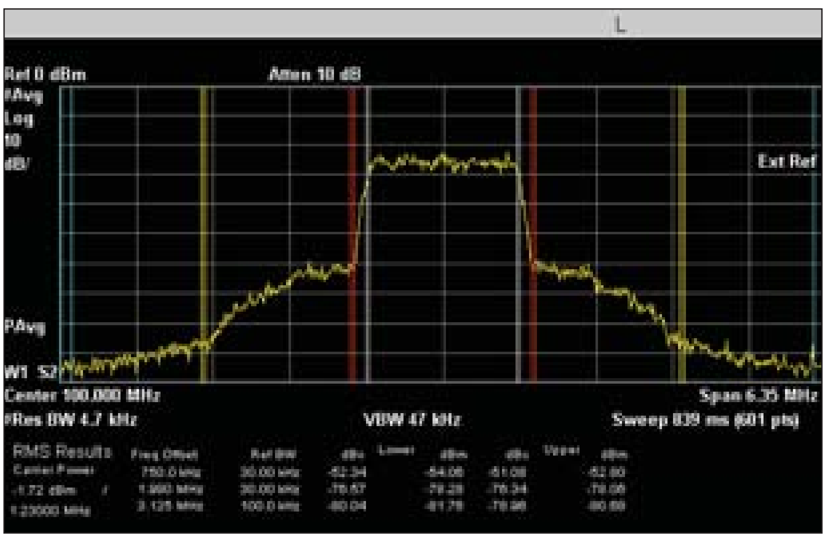
(b)

Figure 6 – IF output spectrum for the (a) HMC400MS8 and (b) HMC316MS8 mixer

Measurements were performed to study the impact of IP3 and spurious performance on a CDMA channel. For a CDMA signal, the 3rd order products create the “shoulders” of the channel response and directly impact ACPR. Figure 7(a) shows the IF output of the HMC400MS8 mixer driven with a strong CDMA signal centered at 1.85 GHz with a channel power of +6 dBm. The ACPR was measured at -64 dBc at the IF output. In Figure 7(b), the HMC316MS8 was driven by the same CDMA signal and the impact of the mixer IP3, in this case 10-dB lower than the HMC400MS8, can be clearly seen in the lower ACPR.



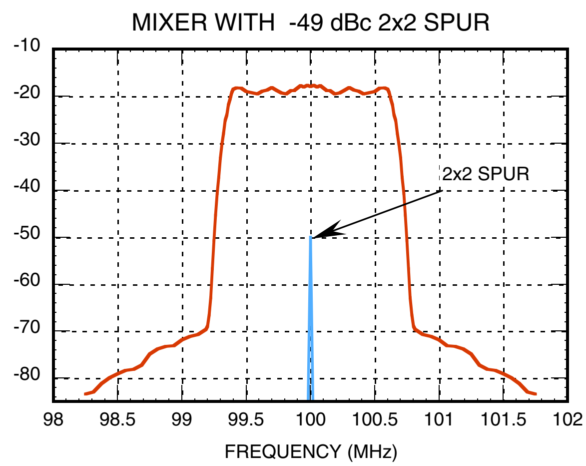
(a)



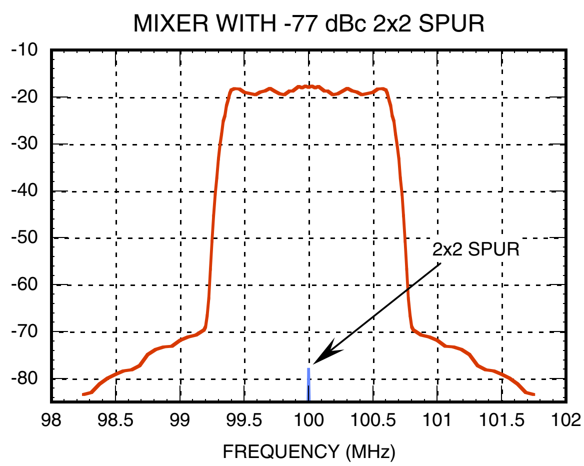
(b)

Figure 7 – CDMA output spectrum for the (a) HMC400MS8 and (b) HMC316MS8 mixer

In order to observe the effects of spurious signals on the CDMA channel, a =SPECTRASYS= simulation was performed in order to view the spurious signal inside the CDMA channel. In figure 8, the same two mixers are compared for their 2x2 spurious responses. Comparing figure 8(a) and 8(b) the superior spurious performance of the HMC316MS8 mixer is clearly reflected in the spurious response at 100 MHz.



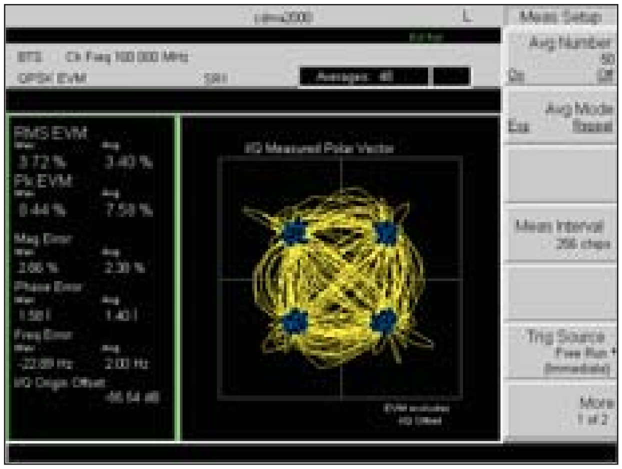
(a)



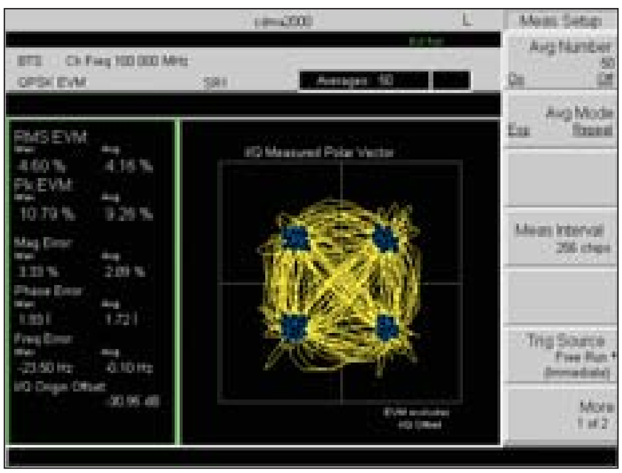
(b)

Figure 8 – Simulated spurious performance of the (a) HMC400MS8 and (b) HMC316MS8 mixer

In order to see the effect of the spurious signal on the CDMA channel, a measurement of EVM was made on both mixers with the results shown in figure 9. For this measurement, an interferer centered at 2 GHz with +4 dBm power was injected into the RF port of the mixer along with the CDMA signal with -8.6 dBm channel power. The interferer signal was toggled on and off in order to observe the effect on measured EVM. In figure 9(a), the HMC316MS8 mixer EVM was measured at 3.4% with the interferer present and 3.4% with no interfering signal. In figure 9(b), the HMC400MS8 mixer also has and EVM of 3.4% with no interferer, but a noticeable degradation to 4.3% with the interferer present.



(a)



(b)

Figure 9 – Measured EVM performance of the (a) HMC316MS8 and (b) HMC400MS8 mixer

Conclusion

Increasing the linearity and dynamic range of a cellular receiver will lead to improved system performance, measured by decreased BER and EVM. The dynamic range of the receiver is dependent upon the linearity of the receiver front end which includes the mixer. The use of high IP3 mixers improves the ACPR, EVM, and BER of the receiver. While the IP3 performance of the mixer is critical to the linearity of the receiver, good spurious performance from the mixer is also important in maintaining the quality of the digital channel.

(Endnotes)

[1] =SPECTRASYS=, RF and Microwave Linear simulation software, Eagleware Corporation, Norcross, GA

Notes:

Notes:

SUBHARMONIC vs. FUNDAMENTAL MIXERS FOR HIGH CAPACITY MILLIMETERWAVE RADIOS

Introduction

The microwave and VSAT radio market in the past decade has significantly grown from primarily voice and data communication to a mix of data, video, internet, and voice services. These newer standards require complex digital modulation schemes which have higher bandwidth requirements, which in turn require higher transmit frequencies. The point to point frequency spectrum ranges from 2.11 GHz to 42 GHz.

To meet the low cost and reliability requirements of these microwave radios Hittite Microwave Corporation has designed integrated MMIC circuits that meet these new market demands. These new devices include components such as mixers, VCOs, prescalers, attenuators and amplifiers to integrated down-converters, up-converters, frequency multipliers, phase-locked oscillators (PLOs) and multi-chip modules (MCMs). Figure 1 shows a block diagram of a typical microwave radio transmit and receive chain in a typical super-heterodyne architecture.

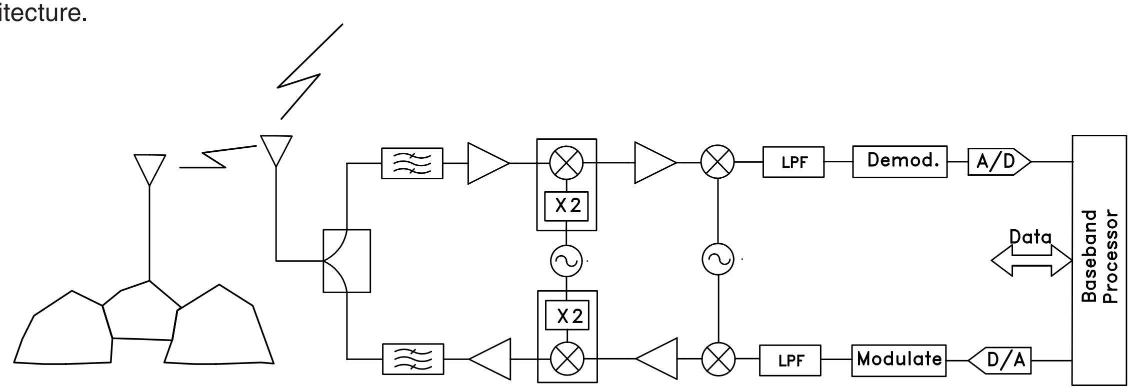


Figure 1 - Microwave super-heterodyne point-to-point radio

The transmit and receive chains both contain amplifiers and mixers which are realized as Microwave Monolithic Integrated Circuits (MMIC). The amplifiers typically incorporate some type of automatic gain control to prevent saturation of succeeding components, particularly the analog to digital converter. There are filters at the transmit and receive frequency to reject interference and spurious products generated by the amplifiers and mixers as well as out-of-band interferers. The mixers shown in figure 1 are comprised of both subharmonic and fundamental mixers. The subharmonic mixers require a local oscillator (LO) signal which is at approximately ½ the RF frequency. These mixers create the majority of spurious signals present in the receiver and transmitter. Since the levels of the spurious emissions will drive the complexity of the filters, a mixer with good spurious performance and a carefully-designed frequency plan is required.

Hittite Microwave Corporation offers a variety of millimeter-wave subharmonic and balanced mixers that meet the requirements for millimeter-wave radios. Hittite's line of sub-harmonically pumped mixers range in frequency from 14 – 42 GHz making them ideal for millimeter-wave radio applications. These mixers are available with an integrated LO and IF amplifier in a SMT leadless chip carrier package as well as die. The excellent 2LO to RF and IF isolation minimizes the transmit and receive filter requirements. The mixers with integrated LO and IF amplifiers require only a single DC bias and -4 dBm of LO drive.

This product note will discuss and compare the use of a subharmonic mixer and double-balanced mixer in the 27 GHz millimeter-wave radio band.

Criteria for the Front-end Mixer

The subharmonic mixer is the primary front end mixer found in the majority of millimeter-wave radio designs. What makes this mixer unique is that it operates with a LO frequency at ½ the RF frequency, therefore eliminating the requirement for a more complex and costly high frequency LO. The subharmonic mixer also naturally rejects even-order spurious emissions. A carefully designed mixer can achieve 2*LO isolation as high as 35 dB. Prior